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Aluminium Cast Iron

There are many reasons in this age of alloy cast iron why aluminium additions in the foundry should receive detailed attention. Aluminium is cheaper than some of the other additions; it alloys readily and is already well established as a useful addition in the steel foundry. Again, some of the aluminium-iron alloys are well known among the heat-resisting metals, so that aluminium cast iron might at first sight appear to offer a solution of the fire-bar problem, apart from any other advantages it may posssess.

To-day, however, aluminium cast iron is little developed, in spite of the fact that it has not been neglected from the research point of view, and has on many occasions received detailed attention since Keep first investigated it in 1888. The principal recent researches have been carried out by Everest in this country in 1925 and Piwowarsky in Germany in 1933. A new investigation, conducted in France by Ployé, has just been reported and will be reviewed in detail in one of our next issues, but it is felt that no new outstanding conclusions can be drawn from this latest work.

The predominant factor in the use of aluminium in ferrous metallurgy is the facility with which it is oxidised in the metal. This leads, on the one hand, to the useful application of small additions in steelworks' practice as a deoxidiser—and it is of interest to note that Ployé has investigated aluminium from the same point of view in the iron foundry; but, on the other hand, it leads to excessive trouble in obtaining sound, clean castings, and this has up to the present been the biggest stumbling block in the investigation and application of aluminium cast iron. That this trouble is not insuperable is, however, shown by the use of aluminium in iron castings for nitriding, but in this case the alloy iron is cast under special conditions, which up to the present could not be considered generally applicable.

A point of further interest applies to cast iron containing proportions of aluminium over 20 per cent. It has been found that such irons are unstable, tending to decompose due to the reaction between the aluminium carbides they contain and atmospheric moisture. Castings in such metal have the somewhat disconcerting property of disintegrating into a heap of powder. So far no useful application of this property has been found, although some future inventor may find in this high-aluminium cast iron just the material he needs for some peculiar purpose.

In his recent report Ployé has considered very thoroughly the possible development of aluminium cast iron from many points of view, and there is much in it to interest both the theorist and the practical man. The ground covered is wide, but, from a general point of view, it is similar to that covered by Everest, and reference to THE FOUNDRY TRADE JOURNAL for August 25, 1927, and December 22 in the same year will show that many of the results obtained and the conclusions drawn agree very closely in the two investigations, in spite of differences in details of technique.

Recruits for Industry

Some passages in the report of the Board of Education for 1934, just issued, have had a very mixed reception. The report says that some readjustment of the relations between industry and the schools will be necessary if industry is to maintain its efficiency, and that changes in the educational system have had an effect not yet fully appreciated on the social and industrial life of the nation. This, it is suggested, is affecting industrial recruiting. In some industries a shortage of juvenile labour is already foreseen, and the number of young people in training is insufficient even for present needs. There is danger that prolonged attendance at school may tend to divert boys and girls from industrial occupations, or to lead them to the office rather than the workshop. The decay of apprenticeship has contributed to these difficulties, which are increased by the cream of the juvenile population being withdrawn to secondary schools.

Now this general statement has in some quarters been met with indignation. It is said that for a generation or more educationalists have been warned that education is becoming more and more divorced from reality, that it was placing a premium on the black-coated occupations, inclined to be snobbish at the expense of the craftsman, and now that the mischief has been done the Board turns round and tells employers that they are not keeping sufficiently in touch with modern educational developments.

Our own view is that the competition of interest in office and factory jobs will settle itself. There is a reaction setting in against snobbishness in all walks of life and the young realists of to-day are unlikely to put up with black-coated jobs merely because they are respectable or clean, unless they are better paid and offer better use of the employee's powers than factory jobs. Secondly, we do not assume that extending the school-leaving age will make

(*Concluded on page* 144.)

XUM

Basic-Electric-Furnace Slags

PAPER TO AMERICAN SYMPOSIUM

At a meeting of the American Institute of Mining and Metallurgical Engineers, held recently, a symposium was organised on "Slag Control in the Making of Iron and Steel." The various Papers are now published as Technical Publication No. 625. We append in condensed form the Paper by MR. H. F. WALTHER on "Slag Control for Basic Electric-Furnace Steel."

Basic electric-arc furnace steel production mainly involves the use of two separate types of slags. The first, known as the "melt down" or oxidising slag, which is in most cases removed from the furnace mechanically, and the heat finished under the second or deoxidising slag, which is commonly known as the "finishing slag." The melt-down slag is formed by the addition of lime or limestone to the charge, which combines with the oxides formed during the melting period and the product of any bottom erosion that may take place. Under ordinary conditions this slag will be of the high-lime type and slightly oxidising. The oxidation of phosphorus and silicon takes place in this slag; also some carbon and manganese is eliminated along with any other element of an oxidisable nature that may exist in the charge. The reduction of these elements is dependent upon the degree of oxidation which is easily controlled. In some special cases the charges are melted without any oxidation, where it has been found practical to melt selected scrap in such a manner so as to conserve the residual alloys.

Aluminium Borings Used

There are several types of finishing slags in use in making the various steels. The lime-silicon slag is used widely in the making of the low-carbon steels, which include the stainless types. This method of slag-making has been found satisfactory where the possibility of carbon absorption due to the use of carbon in the slag as a reducing agent would constitute a melting hazard. The lime-aluminium slag is used to some extent where aluminium borings are available at a low cost. In forming this type of slag it is necessary to use lime of a very low silica content, since aluminium is a very powerful deoxidiser, and easily reduces any silica in the slag. The lime-silica slag is used on some steels to impart some definite physical characteristic to the resultant product. In producing steel with this type of slag no deoxidiser is added to the slag, the value of the slag being dependent upon a fixed lime to silica ratio. There are several other methods of forming slags with special compounds for which merit has been claimed.

Calcium Carbide Slags

Most of the electric-furnace steel of the engineering grades is made with the calcium-carbide slag as the finishing slag. When properly handled it is a powerful deoxidiser and can be so controlled that the chemical composition of the bath can be held within very close limits. It is also one of the deciding factors in the control of inherent grain size, which has become a metallurgical requirement in most steels.

Obviously, if consistent results are to be obtained, it is absolutely necessary to systematise the melting procedure. The day of haphazard melting has disappeared, and in its stead is found the production of steel of superior quality with consistent characteristics, which is possible in the electric furnace.

When a heat of 0.50 per cent. carbon steel is ready to be slagged off, the slag will analyse approximately as follows:—Calcium oxide, 48.78 per cent.; silica, 23.40; ferrous oxide, 8.93; manganese oxide, 5.26; magnesium oxide, 7.10; ferric oxide, 1.92; phosphoric acid, 0.24; alumina, 1.50; sulphur, 0.17; calcium fluoride, 1.20 per cent. This typical oxidising slag compares closely to an open-hearth slag.

If the slag is slightly foamy and the bath is reacting lightly, it is a true indication that the charge is completely melted, and the bath is in proper condition to be deoxidised. The initial slag requires from 40 to 50 lbs. per ton of limestone in the charge, or its equivalent in burned lime. Care must be taken that the temperature of the bath is correct and the slag is in proper shape at the completion of the melt. Ease of control of the heat is dependent upon the condition of the bath at the slagging-off period. The oxidising slag should be removed from the furnace as cleanly as possible, since the objectionable phosphoric acid would be easily reduced in the following slag.

Eight Main Factors

The success of efficient slag control during the deoxidising or finishing periods depends upon the following eight factors: (1) moisture-free materials; (2) consistent chemical and physical characteristics of the materials; (3) correct temperature of the bath; (4) quick fluxing action; (5) proper slag volume and mix; (6) power input; (7) time, and (8) bottom upkeep.

TABLE I.—*Effect of Time on Finishing Slag.*

	Chemical composition. Per cent.	
	45 min. after "slag off."	1 hr. 45 min. after "slag off."
Carbon	0.53	0.77
Calcium carbide	3.68	2.54
Calcium fluoride	5.90	2.80
Calcium oxide	57.84	60.62
Silica	21.86	24.54
Chromic oxide	0.05	0.03
Alumina	2.76	3.08
Ferrous oxide	0.43	0.29
Ferric oxide	Nil	Nil
Manganese oxide	0.17	0.09
Magnesium oxide	4.96	4.24
Phosphoric acid	0.06	0.07
Sulphur	0.36	0.36

The hydrogen set free by materials containing moisture is easily absorbed by the hot metal. Chromium steels are particularly vulnerable when silicon is present, and if hydrogen is present in any appreciable amount it will cause porosity in the top section of the ingot as it is released during solidification. Since little is known as to the elimination of this gas in the furnace, the obvious procedure is to keep all hydrogen-forming compounds out of the furnace. The lime, sand, fluorspar, coke or any of the fluxes in common use must be constantly checked if consistently-uniform slags are to be made. The bath temperature must be closely controlled, since varied temperatures during melting and pouring of a particular type of steel impart somewhat different characteristics to the slag and the finished product.

Finished slags should be designed to flux quickly. The mixture is dependent mainly on the type of burned lime available, since its composition varies greatly and reacts with varying results in the furnace. When grades of slag-forming materials have been decided upon, it will be advantageous to mix them in their proper proportions and charge into the furnace after slagging off. Some carbon in the form of crushed coke or crushed electrode can be added to this mix in the higher carbon steels, but is not advisable for low-carbon types. Enough coke should be spread on this mix to form calcium carbide and establish deoxidation, and to insure that hot carbon-monoxide gas is produced in sufficient quantity to build up a positive, or outward, pressure. This prevents excess air from entering the furnace and maintains the furnace atmosphere and slag in as perfect a reducing state as possible. To facilitate this condition it is essential, of course, that the furnace be sealed as tightly as possible and that there be no water leaks.

Depth of Slag

Practical considerations play an important part in determining the proper slag volume. It must be of sufficient volume and viscous enough to prevent excess coke from coming in contact with the molten metal, thus assuring close carbon control. There must be enough slag present to prevent the arc from contacting the metal directly, as the reactance on the slag is less, when of the proper composition, than on the metal, thereby permitting a smooth and steady power input. And finally, there must be enough slag to conserve the temperature of the metal in the ladle to the end of the pour.

Maintaining the delicate electrical equipment of the modern high-powered furnace is absolutely essential to efficient operation and slag manipulation in the hands of a skilled operator.

Slags, when efficiently made, should be in a nearly perfect condition 45 minutes after slagging off (Table I). It is evident that no real constitutional difference existed between the time the first slag sample was taken and one hour later when the heat was ready to tap. From the analyses both slags are indicative of being in a highly-deoxidised state. While calcium carbide is a strong deoxidiser, it remains for silicon and aluminium completely to degasify the metal to produce sound ingots, the use of which, however, can be held to a minimum.

Since the slag is practically free from all heavy oxides, it is obvious that subsequent additions of ferro-alloys cannot be oxidised in this type of slag, and will go into the bath without loss. Since completely deoxidised steel can be made in the furnace without resorting to ladle additions, it is evident that clean steel can be made by efficient furnace operation and slag control. Considerable attention must be given to the materials used in the bottom and lining of the furnace, since erosion is an ever-present problem, the results of which are readily reflected in the slag and quality of the steel.

The question often arises as to whether the slags can be controlled as easily in the 100-ton furnace as in the smaller furnaces, and it is believed that they can. Experience has taught that standardisation is increasingly important with the increase in furnace capacity, and if followed judiciously will result in the production of steel of superior quality with the melting hazard at a minimum.

Recruits for Industry

(*Concluded from page* 143.)

things worse. If the Board takes its own warnings in time against the effects of a purely literary education and makes arrangements accordingly, they may be better for the industries. Finally, we do think that employers as such have not sufficiently kept in touch with education, and we would like to see some means established whereby they could express their views and make them effective, considering the amounts they pay in local and national taxes for education. We believe that educationalists would welcome this interest, and until they get it they can scarcely be blamed for doing the best they can. For instance, it might help to dissuade employers from asking for matriculation as a leaving certificate, which at present stultifies a large part of modern secondary education.

Cupola Refractories

PROFESSOR T. TURNER ON CARBON DEPOSITION

The discussion on the Paper* on "Refractories for Foundry Use," by MR. W. J. REES, M.Sc., presented to the Sheffield Conference of the Institute of British Foundrymen, would have probably developed into one of great importance but for the lack of time. As it was, many interesting points were touched upon, but only in a general way. The discussion was opened by MR. V. C. FAULKNER (Past-President), who said that Mr. Rees had stressed the necessity for dimensional accuracy, but like others he usually pointed out in the phrase immediately following the importance of using a minimum amount of cement. Another feature to be borne in mind, however, was the convexity of the surface; if there were a convex surface a good deal of pressure was applied locally, which would reduce the melting point of the brick.

Another factor was that in the early life of any furnace structure there was a vast amount of erosion and corrosion; but, after the thickness of a wall was reduced, say, from 9 in. to 4½ in., it would "stay put" for a long time. That phenomenon was obviously connected with the heat conductivity and the cooling effect upon the refractories, and Mr. Faulkner drew attention to this point so that it might be taken care of in research, with the object of determining, prior to the construction of the furnace, the most desirable thickness of the wall.

Finally, he asked if Mr. Rees had had much experience of painting walls immediately after construction in order to induce a glaze very quickly.

Blast-Furnace Linings

MR. F. S. RUSSELL (General Refractories, Limited) expressed great indebtedness to Mr. Rees for his Paper, which was as able a contribution and as full of insight as all contributions he had made towards their knowledge of metallurgical and refractory problems.

With regard to blast-furnace linings, which subject had received a great deal of consideration in recent years, Mr. Russell pointed to the modern movement in favour of high-alumina bricks—bricks containing more than 40 per cent. of alumina. He asked if Mr. Rees would say whether he considered that that movement was likely to go further—whether it was likely, for instance, that a brick containing 45 per cent. alumina would give better results than one containing 40 per cent., whether a brick containing 48 per cent. would be better than one containing 45 per cent., and so on. Was there any real sound basic reason for this preference for high-alumina brick in blast-furnace linings, or was it merely based on the theory that the higher the alumina content, the higher the refractoriness of the brick?

He also asked whether it was part of the theory that high-alumina bricks in a blast-furnace lining resisted decomposing agents better than would an ordinary fire-clay brick containing perhaps 34 or 35 per cent. of alumina.

Jointing Cements

It was pleasing to note that the problem of jointing cements had received special mention in the Paper. All who were concerned with furnaces and kilns had had experience of the failure of bricks because of the way in which the bricks were bonded during building. Very occasionally it was due to the refractory (laughter), but Mr. Russell felt sure that in most cases the greater part of the trouble could be traced to the jointing cement. People held loose ideas with regard to jointing cement. He had seen expensive silica bricks, carefully made, fully converted, fully of tridymite and crystabolite, put together with joints more than half-an-inch thick in which was used a cement consisting to the extent of about 50 per cent. of a very ordinary fire-clay, the other 50 per cent. consisting of old silica bricks ground up, a little sand being added. Of course, a nice fat, sticky cement like that would work a great deal more easily on the trowel than would a really high-class refractory silica cement, and there was no doubt that even now, despite the advance of scientific knowledge, far too much latitude was allowed the bricklayer in regard to the cement he used with expensive firebricks. Mr. Russell said he had also seen a brick kiln, which was to work at a high temperature, being built of fire-clay bricks, the cement for the jointing of which was made in his presence and consisted of at least 25 per cent. of ordinary mortar. After a while, of course, the joints began to weep, the droppings from a joint would run down the face of the brick below it, and melt that brick, and formed with that brick a mixture which helped to melt the next brick. That state of affairs continued until all the surface had become glazed, then sooner or later, the joints were hollowed, so that the destructive gases and dusts got into them, undercut the bricks and reduced their life by about 50 per cent. As a result of this sort of thing, the firebrick manufacturer was blamed, and only because he had not had the opportunity of checking up the material used with his bricks in the construction.

Ground Ganister

Mr. Russell said that one never heard a solitary voice raised about ground ganister during the course of all the mass of research work, despite the fact that so many Papers were produced dealing with such kindred subjects as "Silica Bricks" and "The Classification and Testing of Sands." It seemed to him that ground ganister, which was the commonest refractory of all, and was a term that covered a multitude of sins, received the least scientific attention of any refractory known to industry. So much depended on ground ganister, that it was high time that people realised they could not buy any kind of common rubbish and yet obtain good results. It was the custom in some places, though not in the Sheffield area, to make ground ganister out of material which was not good enough for silica brick making. Such a mixture, though cheap, was unsatisfactory, and people must not complain if they did not secure good results from it. His experience, supported by that of Mr. Rees, was that perhaps the most important feature of a good ground ganister was the particular type of clay used in its production. Not only must that clay be highly refractory, but it must be very sticky, so that as little as possible of it could be used to give the desired result. But all the clays which possessed those two virtues were expensive; so that it was really impossible to produce a high-class, reliable and successful ground ganister at other than a reasonable price.

Carbon Deposition

PROFESSOR THOMAS TURNER (Emeritus Professor of Metallurgy, Birmingham University) was glad to have the opportunity of commenting upon the Paper by his old friend Mr. Rees, who was in Birmingham for a number of years, where he had always been very helpful and friendly.

With regard to the problem of carbon deposition, which occurred in the cooler parts of the cupola, and was sometimes noted very much in blast-furnace work, if by any oversight one used refractories in which there was a quantity of oxide of iron, Professor Turner said it was astonishing how much carbon could be deposited in those circumstances. A little globule of iron was reduced and it continued to act upon carbon monoxide so that more and more carbon was deposited until, if the process were allowed to proceed, the carbon became very much more bulky than the original brick on which it had been deposited. That was an extreme case, of course, but it had occurred not infrequently within his own practical knowledge.

Discussing the important question of the strength of a refractory at its higher working temperature, he said one might have two refractories, one of which would be regarded as of inferior quality, but at a high temperature it would withstand greater pressure and more knocking about from the charge than would the one of higher quality. It was a question of the toughness of the refractory at high temperature, so that, as Mr. Rees had pointed out, it might be an advantage in some cases to have a refractory giving a lower cone temperature but which at the same time would be more effective in practice.

Cases of Over-Insulation

With regard to the lagging of the furnace, to prevent heat loss, he recalled Mr. Faulkner's reference to bricks becoming gradually eaten away inside the furnace until their thickness was reduced to perhaps half the original thickness. If that process were continued indefinitely, of course, the bricks would wear until the outside of the furnace was reached, and relining would be necessary. But there came a stage at which outside lagging might not be economical. Several cases had been brought to his notice in which it had been found more economical to lose a little heat than to reduce the outside losses, because by reason of the lagging the firebricks inside had melted more quickly, so that the furnace had to be relined earlier, involving more frequent interference with its operation. It paid better to lose a little heat than to lose the firebricks. Ultimately, of course, it was a question of balance, and a question of economy; but external cooling of a furnace was sometimes more important than the actual chemical composition of the material used for lining it.

Refractory Cements

Discussing the cement used between the bricks, he said that as a general rule the less cement one could use, the better. But if a cement had to be used, it should be of the highest quality. He recalled having been consulted some years ago at a works at which considerable trouble had been experienced. The works were rolling good material—a special quality wrought iron—and in the rods that were rolled there were inclusions of a material the colour of which was nearly white, but it obviously was non-metallic, something in the nature of a white slag. They could not trace this trouble. When he had looked into the re-heating furnace he had seen tears form on the roof and drop down upon the piles of material that were to be rolled, so that they were rolled into the material and had spoiled it for the purpose for which it was intended. He had inquired what clay had been used for the jointing and was told that they had some very good local clay, samples of which they had shown him. He had examined it and had found that although it looked very much like fire-clay it was not fire-clay at all, but was the commonest material. That was only one illustration within his experience of how considerable expense and trouble were involved due to attempting false economy. There was no doubt that if one were to build good structures of fire-clay materials, such jointing as was necessary should be made of material at least as good as that of the bricks themselves.

MR. J. H. COOPER, having expressed his appreciation of Mr. Rees' valuable Paper, said its usefulness would be increased if Mr. Rees would warn people using refractories concerning the amount of limestone which would enable them to secure a really better life from a refractory. Also, did he consider it possible, for example,

(*Concluded on page* 147.)

* FOUNDRY TRADE JOURNAL, July 18, 1935, p. 47.

Present Position of the Cast-Iron Test-Bars

LARGE TEST-BAR RESULTS AND HEAVY CASTINGS

The discussion—reproduced below—on MR. HARBACH'S Paper* presented to the Sheffield Conference of the Institute of British Foundrymen, showed clearly that the two schools of thought as to the desirability of increasing the requirements from existing test-bars are still irreconcilable. This position will exist until some individual can devise a scheme for providing very large quantities of metal economically within a really short space of time at very infrequent intervals.

Opening the discussion, MR. J. G. PEARCE began by saying that it was just the kind of Paper he had hoped some of his own earlier efforts would stimulate; the kind of Paper in which an experienced metallurgist collected, examined and analysed the results of test-bars of widely varying ranges of sizes on a range of mixtures. The proposal regarding the 1.655-in. bar would be of great interest to those members of the Institute who were concerned with framing specifications. It was quite correct that a 1.655-in. dia. bar broken at 24 in. centres gave theoretically the same breaking load as a 2-in. by 1-in. bar broken upright, tested at 36 in. centres, but, as Mr. Harbach's Table I showed, in fact the former would be stronger than the latter. Theoretically, the strengths were the same, but practically the round bar was stronger.

Round Bars have Superior Strength

It was shown in his laboratory some years ago that, other things being equal, a round bar was always stronger than a square bar. That difference had nothing to do with casting conditions, because it remained true even if the square bar was made from one which was originally cast round, and if the round bar was made from one originally cast square. The difference was due, probably, to the manner in which the stress distributed itself in transverse across the section of the bar. The result was that the 2-in. by 1-in. bar broken at 36-in. centres broke at a load almost identical with the 1.655-in. bar at 24-in. centres if the latter were made a little bit smaller. If it were made 1.6 in. instead of 1.655 in. the loads should be about the same. The difference was, roughly, about 10 per cent.

New Series of Bars Suggested

This suggested that a very convenient range might be obtained for bars for testing purposes if, say, there were diameters of 0.8 (instead of 0.875), 1.2, 1.6, which was Mr. Harbach's new bar practically, and 2 in., each tested at a span equal to 15 dias., respectively, 12 in., 18 in., 24 in. and 30 in. A 2-in. bar 30 in. long was a big bar, but, after all, it was not so long as the 36-in. bar which had been used for so many years. Those four bars had diameters with ratios of 1, 1½, 2, 2½, and the ratios of the areas were, roughly, 1, 2, 4 and 6. He made this suggestion because there was a sort of completeness and uniformity about the range which was very attractive when Mr. Harbach's suggested bar was considered. The big 2-in. bar, 30-in. centres, was much more convenient for testing machines than the 2.2-in. bar at 18-in. centres. Mr. Harbach had given data with respect to the relationship between transverse and tensile which would be of great value in framing specifications. There was a point to be borne in mind. Table I showed the amount of material removed by machining in a tensile test varied greatly from bar to bar. The amount of material removed was bound to affect the transverse-tensile ratio. The present tensile bars were originally based on B.E.S.A. bars for standard steels. There was no reason why tensile bars of standard diameters should be adopted for cast iron merely because they were convenient for something else.

Test-Bars from Maker's Angle

There was a great deal to be said for not removing more metal than was definitely necessary in the tensile test. He always regarded the testing question from the maker's point of view, and he had reluctantly concluded in the past that in many cases iron was tested in such a way that the maker got the worst possible result he could get. The results could be improved very considerably from the point of view of the maker as Mr. Harbach had shown, by machining the transverse bar. He could confirm all that that gentleman had said concerning the influence of machining the transverse bar. It increased the strength considerably, and it was the standard practice in the laboratories with which he was associated. He did not say it need be done regularly in routine testing, but it was important to know what the difference was. If a result was unduly low it was possibly due to a superficial effect, and one might try the effect of machining the second bar.

The improvement also increased the ratio with the tensile test. He could also confirm the statement as to the favourable effect of the shorter span on the modulus rupture. This was something which was not expected but cast iron behaved in that way. In theory, if the bar was shortened there was such a change in load as compensated for the shortened span; the span and the load were interdependent. It would be found that in the case of cast iron this did not happen; the shorter the span the higher the breaking load went up in proportion. The difference, however, was not great.

"Transverse Rupture Stress" Preferred

MR. P. A. RUSSELL, B.Sc., wished to endorse the statement that the Paper was a very valuable one to all those concerned in the framing of specifications. The data provided would be extremely helpful. He was very glad that Mr. Harbach had emphasised the transverse rupture stress of cast iron as distinct from the ordinary way of expressing the breaking load. This could not be drilled sufficiently often into the minds of the members of the Institute. Many of the obstacles in the way of transferring thought from the old 1 in. square and 2 in. by 1 in. bars would be overcome if members would use the transverse rupture stress more frequently. The necessity for matching up the old 2 in. by 1 in. bar by the 1⅛ in. dia. bar would be eliminated.

One of the outstanding points in the Paper which had appealed to him was the machining of the transverse test bar. It appeared to be so important that, in his opinion, provision should be made in any future specifications for machining the bars if desired. The effect seemed to be very great. Mr. Harbach had obtained an unexpectedly high test at the top of a long runner as against the bottom. He suggested that was due to the annealing effect of the casting against the bottom of the runner, whereas the top of the runner would be much more isolated.

The Problem of Fixed Ratios

MR. JOHN SHAW regretted he disagreed with both the previous speakers. He had read Mr. Harbach's Paper with interest. The large number of experiments he had carried out could not but be of benefit to himself and his firm. At the same time practically all the experiments had been carried out a number of times before. As shop routine tests they were valuable, and also gave the engineer some rough idea of the ratio of the various tests and the reduction of strength with increase in section. But, he thought, no one would wish in a National Specification for the breaking transverse load to be dependent on a fixed ratio of the tensile result. He would take Mr. Harbach's own figures in the Paper, where under his closely-controlled conditions the ratio on the 2-in. by 1-in. bars fell between 2 and 1.5. This might not seem much, but if a 15-ton tensile bar was taken, and multiplied by the two ratios, the transverse might be either 30 tons or 22.5 tons, a difference of 7.5 tons. A point that was so often overlooked was the fact that the inspecting engineer did not control the foundry. While it was possible in a well-controlled foundry to establish some near ratio between these two tests, he had no hesitation in saying that the ratio would vary from shop to shop, sufficient to make it futile as a safe guide.

Span and Diameter Ratios Misleading

Mr. Harbach raised the span/diameter ratio in relation to the 2.2-in. bar. He could assure him that this point was thrashed out in Committee and was deliberately turned down. It implied to the engineer that the same modulus figure could be obtained from a large bar as from a small one. Therefore, it might mislead. The economic side was also a factor. At that time nearly all the national spending departments insisted that the bars should be cast on. Hence there might be a bar 36 in. long to cast on a small lumpy casting. The Committee, therefore, after many experiments, made the bar as short as would yield a reasonable deflection. That their figure was right was lately confirmed by Mackenzie, who found little difference in the deflection of the 2-in. bar when tested either at 18-in. or 24-in. centres.

He agreed that with the round bars so easily skin machined, transverse tests would be more accurate if machined.

Mr. Harbach had quoted some results when using the tentative ASTM specification. These low figures were explained by the shape of the tensile piece as cast. It was of dumbbell form, and for the 1.2-in. bar was increased to 2 in. at each end. The re-annealing effect of these heavy lumps reduced the tensile in every case, and was further evidence how doubtful it was to attempt to convert one test into terms of another.

Tensile Strength Unsuitable for Classification Purposes

It was also stated that tensile would probably prove the more suitable means of classification for high-strength iron. He disagreed with this statement. With this type of border iron it had been proved over and over again that while there might be a high tensile, the transverse often failed. Hence the present search for a suitable impact machine. The impact results put before the A.F.A. were disappointing when compared with the tensile results. The transverse test gave a better idea of the quality of the iron.

The Founder and the Large Test-Bar

While it was generally accepted that the time was ripe for a revision of Specification No. 321, or the framing of an entirely new specification to bring the increased strengths of modern cast iron into line, it was open to doubt if the tendency shown by some members of the Committees, both here and in the States, would be acceptable to the heavy founders. To cast a

* FOUNDRY TRADE JOURNAL, July 25, 1935, p. 61 *et seq.*

2.2-in. bar from either crucible, small oil or electric furnace that gives high tensile tests was one thing, to make a casting of 15 to 20 tons with this type of metal was quite a different proposition. How far such a metal was even suitable for a large number of castings that now have to meet a specification was open to serious doubt. From a careful search over a number of years he had only found one 2.2-in. dia. bar that was cast from the same ladle of metal as a large casting that yielded 21 tons per sq. in. That mixture contained 80 per cent. steel (MacPherran). It was invariably found, both here and in the States, that the chief advocates for the large bar to yield the same load per sq. in. are those makers of peanut-sized castings or technical advisers, who, like the signposts, point the way (often wrongly), but have never to travel that way.

AUTHOR'S REPLY

The 16-in. × 24-in. Bar

MR. HARBACH, in reply, said that the results in the original state were determined more or less to satisfy his own curiosity with regard to certain points. The fact that they had got into print, and were presented to the Conference, was due entirely to the President, who regarded them as being useful material. It was gratifying to find that Mr. Pearce and Mr. Russell found so much to confirm their own views. Personally, he was rather inclined to take a serious view of the 1.6-in. dia. by 24-in. bar, because that was actually the first round bar that he ever used, and was really used prior to the adoption of round bars as a standard specification. Therefore, he had taken a sort of fatherly interest in it. He was glad to hear Mr. Russell endorse the need for expressing transverse strength as rupture stress instead of breaking load, as this was the only method whereby the results from different sizes and shapes of bars became comparable, but, even if the method became well established there would still remain a number of people interested who thought of strength in terms of the breaking load of a 2-in. by 1-in. bar—some specifications still call for tests on this bar—so that, apart from other reasons, the use of a 1.6-in. dia. by 24-in. bar would have advantages.

Effect of Machining on Transverse Tests

With regard to the effect of machining on transverse tests, he was inclined to think that it was not possible to make the iron any stronger; therefore it was, to some extent, an advantage to remove the variables which were causing a low result. The relationship to the casting was a different thing altogether, but as long as there was a constant means of testing it constituted a step forward in determining what was the strength of the casting.

Mr. Russell had raised a point with respect to the top and bottom of a 9-ft. runner. He agreed that the bottom was annealed, and being in a pit would account for it, but only the day before he had had results from one which was cast in a box, 5 ft. long and 1¾ in. diameter. The top half was 11.5 tons and the bottom 11.1 tons. It was not a difference of great magnitude, but nevertheless it showed the same effect, although there was no annealing action in the box as there was in the pit.

Transverse and Tensile Ratios

He very much appreciated Mr. Shaw's contribution to the discussion as it was well known he had given considerable attention to this particular subject. He was glad to find the results given were considered useful in establishing approximate ratios between transverse and tensile strengths and the effect of increasing section on strength. It was not suggested that a constant ratio would be obtained in practice so that tensile strength could be accurately calculated from transverse strength, in fact in the conclusion on this point the writer stated "the determination of tensile strength is preferable to estimation from transverse strength."

On the other hand, in Mr. Shaw's calculations the widest ratios for 2 in. x 1 in. bars (2 to 1.5) were taken, but in the results from which the curve was compiled the average was close to 1·8 and 1.7, and only five results were outside the range 1.9 to 1.6; moreover they were not obtained under closely controlled conditions, but from a variety of mixtures over a long period.

High Tensile and Low Transverse

In the main the author suggested that under controlled conditions the tensile could be calculated within ± 8 per cent. or less, compared with ± 14 per cent. shown by Mr. Shaw. He fully agreed that the ratio might vary somewhat between different foundries due to factors which affect the relation between tensile and transverse beyond the usual ranges. In fact this point is mentioned when considering Fig. 5, "factors causing high tensile strength may not necessarily raise the transverse to the same degree," which in a modified form bears out Mr. Shaw's remark that "high tensile irons often fail in transverse," although failure would naturally depend on the minimum transverse required for a given tensile, and results indicated that if the tensile was doubled the transverse could only be expected to increase about 50 per cent.

In the event of a high-test iron giving unexpectedly low transverse result, it might be mainly due to skin defects which, whilst having a marked effect on the breaking load, would have very little effect at working load.

It was admitted that, to people directly concerned with the properties of cast iron, the transverse test was more informative than the tensile test, but to the majority of users and designers who were not so similarly interested the tensile strength was the one chiefly considered so that classification on this basis, together with appropriate transverse figures, would serve both maker and user. So far as a fixed ratio in a specification was concerned, this would only apply as a basis for obtaining the relation between the minimum transverse and tensile required as the actual test results could vary both above and below the orignal ratio providing they complied with the minimum requirements.

Effects of Span/Diameter Ratios

He was aware that Mr. Shaw had given considerable time and thought to the effects of varying the span/diameter ratio. Although he could not claim the same lengthy experience with the 2.2-in. dia. bar, the results of tests on the 1.2-in. and 1⅝-in. dia. bars had shown that when the E value was calculated from the total deflection of bars having a span/diameter ratio of 15 : 1 close agreement was obtained, but with both sizes of bars broken at 12-in. spans the E value dropped roughly in proportion to the decrease in span and then agreed fairly closely with the results of the 2.2-in. dia. bar.

With regard to the suggestion of Mr. Pearce for a 2-in. dia. by 30-in. bar, and Mr. Shaw's objection on account of the length, whilst it was admitted a cast-on bar of this length might prove unsuitable for some castings, recent specifications tend to permit the use of bars cast separately, and when a full-length bar required to be cast on had proved difficult, there had been no objection to the arrangement that a satisfactory tensile result from a shorter bar should be sufficient for acceptance.

It was gratifying to note that Mr. Shaw confirmed that a new specification was required to cover the higher-strength irons now available, and he agreed that specifying the high-strength irons for large castings would often be undesirable, and, in fact, he would go further by saying that such irons would often be unnecessary if reasonable safety factors for irons of medium strength were used. Hence the suggestion that efforts to acquaint users with the properties of cast iron would be rewarded by simplifying the founders' problems and establishing reliable information in the minds of users and designers which would, amongst other things, cancel out ideas that cast iron was still 8 to 10 tons tensile, and a safe working stress should not exceed 2,000 lbs. per sq. in.

It was felt strongly that the more users and manufacturers could meet on common ground the more readily they would appreciate each other's problems to the ultimate advantage of both sides.

Cupola Refractories

(*Concluded from page* 145.)

to use in the cupola a portion of monolithic lining and a portion of brick lining, because one expanded and the other contracted, and by means of such a combination one might avoid difficulties with the joints?

(In view of the shortness of time, further contributions were invited in writing.)

Author's Reply

MR. REES replied to the discussion. Dealing first with the important question raised by Mr. Faulkner concerning the thickness of the wall, he said that in some industries it had actually been found to be beneficial to start with a thinner wall, it having been found that the thinner wall lasted just as long as the original thick wall had done.

It was pleasing also that Prof. Turner had contributed to the discussion, for he had been responsible for the enthusiasm of a good many of those working in Birmingham in earlier years. It had been their practice to go to him with many of their troubles, and such success as some of them had achieved had been due in no small measure to the encouragement he had given them at Birmingham twenty or thirty years ago.

The point raised by Mr. Cooper concerning the possible use of a combination of a monolithic and a brick lining was exceedingly important, and Mr. Rees believed that very definite progress could be made by the proper utilisation of such combinations.

Mr. Rees intimated that he would reply in more detail in writing to the points in the discussion.

Written Contribution

MR. G. W. BROWN (Birmingham) wrote:—The author of the Paper was to be highly commended for putting the matter in such a practical form, and one that could be read and digested with profit by even the man who put on the daubing. It was a subject in which the foundry could do with all the assistance from universities and laboratories obtainable, and in such a practical manner as the present Paper.

The writer would be grateful for a little more enlightenment on the possibility of disintegration through the charging, whether there was likely to be any appreciable difference between the hand and mechanical charging? Also did the shape of the cupola lining, *i.e.*, either straight lined or conical lined, have any effect on the mechanical stress as mentioned?

The author also spoke of the cupola as being heated up quickly. Could he translate this into time, as the writer endeavours to prolong this time to the maximum by keeping a slow fire going all through the night in the cupola to be used the following morning? The emphasis placed on the close jointing is of great importance.

Would it not be possible to arrive at some standard, particularly in the moisture content of the material used for patching, as the life of the lining would appear to be not so much due to the quality of the bricks as the quality of the daily patch in the melting zone and the methods of application?

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Castings

By W. MACHIN and M. C. OLDHAM

(*Continued from page* 140.)

The Non-ferrous Castings

Referring now to non-ferrous materials, a type of casting in connection with which considerable difficulty has been experienced is the liner for use on propeller shafting, made in gun-metal (88 copper, 10 tin, 2 per cent. zinc), known as Admiralty quality. These castings are machined all over, and have to withstand water pressure without showing signs of leakage. Many foundrymen would not hesitate one moment in casting these in a vertical position; it is known that

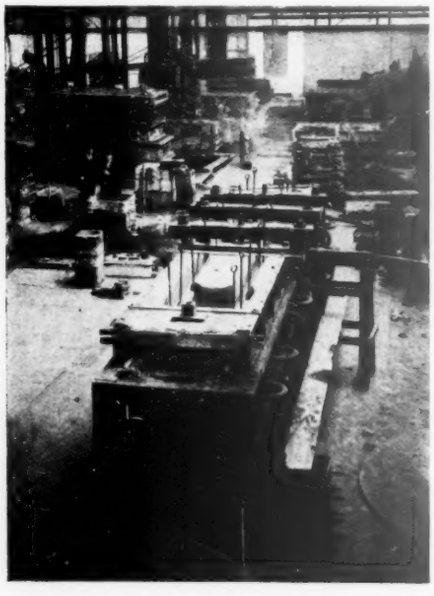

FIG. 35.—THE COMPLETED MOULD.

many are made to-day under that method, in fact, specifications mention in some cases that they must be cast vertical.

The results, however, have not been at all good, the main defect being unevenness due to cooling, causing irregular contraction and varying grain size, though the casting thickness is regular throughout. The best casting method has been found to be horizontal, not vertical, and its construction is shown in Figs. 33 to 38.

The runner basin is shown in Fig. 35 ready to receive 5½ tons of metal. The mould in this instance is set carefully by the aid of a spirit level, it being essential that the metal should rise evenly over the whole length of the job during casting. The runners are all plugged with lift plugs, the intention being to pour the whole of the metal into the basin before any is released into the mould. When the metal is poured, all runner plugs are drawn simultaneously, and the mould very quickly filled, with the result that there is an even temperature existing throughout the entire mass of metal in the mould.

It is obvious that the whole length of the casting will be at the same temperature and contraction will commence and continue evenly all over as it should do. The contraction on this casting was 4 in., *i.e.*, the actual casting was 4 in. shorter in length when cold than the mould was before casting. It is obvious then that the more even one can keep the temperature throughout the whole length of the casting, the more even contraction that will be obtained. It will be appreciated that any drag that may occur, due to uneven contraction, will cause the metal to tear, and if cracks are not seen by the naked eye it is certain that the grain will be disturbed.

Manganese Bronze

Another alloy extensively used by engineers, for many important applications, is manganese bronze or brass. There is a large variety of these alloys in use, differing in composition with the ultimate tensile strengths varying from 28 to 50 tons, with from 12 to 30 tons yield, and 12 to 35 per cent. elongation in the cast condition. These alloys are much more difficult to cast than gun-metal, the shrinkage being very much more pronounced.

The methods of feeding, therefore, are very similar to those for steel, and unless large feeding heads, or local external chills, are used over changing and thick sections, good results in the finished castings cannot be obtained. The use of chills is not considered advisable, except in instances where feeders cannot be effectively used. The method of running is very different from that of steel, owing to the rapid oxidation of the metal due to the high zinc content. It has been found in practice that when casting these alloys the runner should contain a series of skim bridges to clean away the oxide and to prevent its entry into the mould. The distribution of the runners is another important point, practice again proving that equal cooling of the casting gives the more satisfactory results. The correct method, therefore, is that of fixing the inlets into the mould in such a manner that equal cooling of the casting is assured.

The thicknesses in the casting shown in Fig. 41 vary from ½ in. up to 2 in. These are extremely complicated pieces, and it is necessary that great care be used in the making of mould and core. The core (Fig. 39) is made on flimsy lines so as not to retard contraction, the core irons and sand being kept as weak as possible. Fig. 40 shows the core assembled in the mould with

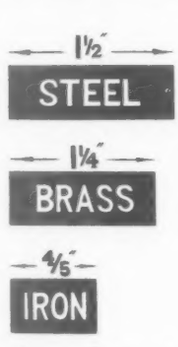

FIG. 42.—STEEL, BRASS AND IRON CONTRACTION ON 8-FT. LENGTHS.

the top part in view showing the position and size of feeders used, together with the two runners, one at each end to maintain an even cooling rate. The runner carries a skim bridge at the bottom. It will be observed how different are the methods required in the running and feeding of each class of metal, and also the variation in the disposition of the feeders.

In the making of moulds and cores, some are reinforced with heavy irons, others are insufficiently vented, whilst others, again, may be badly rammed or packed. Such conditions as these are obviously opposed to the obtaining of quality in the finished product. The various operations in the building of either unit, if incorrectly carried out, are almost certain to produce defective castings.

To illustrate the importance of the mould or core being made on lines just sufficient to withstand the pressure and wash of molten metal and not to hinder contraction, Fig. 42 shows the contraction allowances on 8 ft. of steel, brass and iron. In Fig. 43 contraction fins are shown to have been added to tie the changing sections together; also, the moulding box is put together in sections for quick dismantling. The sand in

FIG. 43.—BOTTOM-HALF MOULD FOR A CAST-STEEL H.P.-TURBINE CASTING.

this mould for turbine castings is no more than 2½ in. thick in any part, all the backing material being of cinder, which crushes during the contraction of the casting.

Propeller-Shaft Bracket.—The thickness of the boss of the casting, the pattern for which is shown in Fig. 44, is 10 in. in places, and at the box end 2 in. to 8 in. It is important that the mould be made so that the part in front of the box, or between the boss and the box, is weak. The weak part is shown where the peg projects through the joint (Fig. 45). The mould on each side at this position is removed quickly during the easing operation so as to allow this portion of the casting to move towards the boss. This is necessary as a result of that part of the casting solidifying much quicker than the boss, which, as stated, is of thicker section. The box is formed with three drawback pieces, instead of one, to facilitate ease of contraction as is shown in Fig. 46. Feeders are used to feed the boss—the top half of the mould is made in two pieces. Fins are added to assist in preventing hot tears during the contraction period, and, also, to tie the changing sections together. These fins are made less than the thinnest portion of the casting, so that they solidify quicker than those parts and give the necessary assistance.

The mould was dried by means of portable hot-air stoves and the temperature taken at five points in the mould after two days ranged from 280 to 320 deg. C. This system of drying moulds is excellent on many classes of work, but some other large moulds of a shallow type are found to be better dried by other means.

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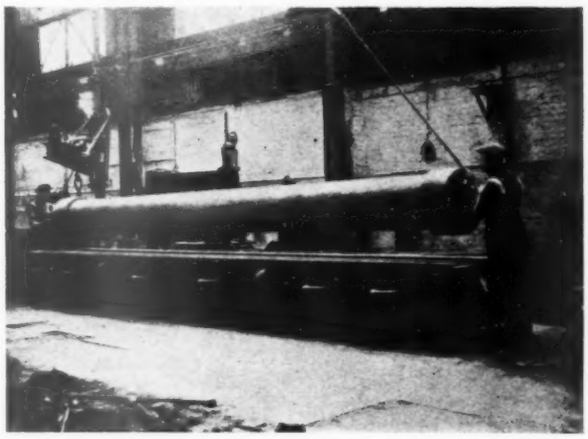

Fig. 33.—Mould for a Gun-metal Liner 21 ft. 3 in. in Length.

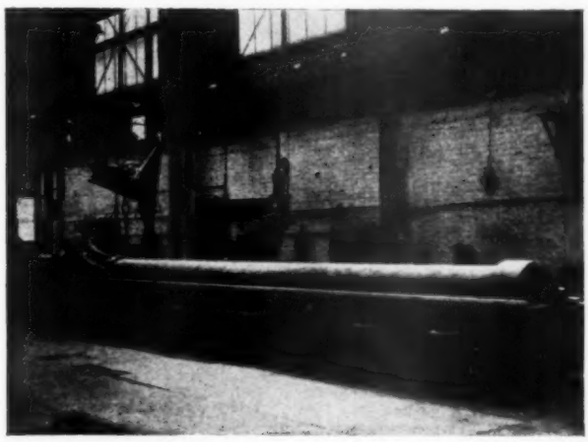

Fig. 34.—Core in Position.

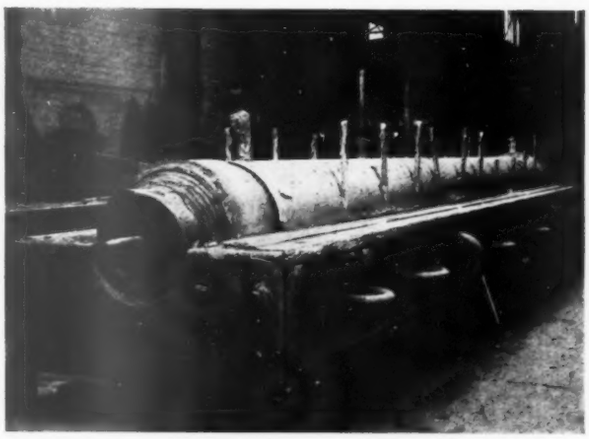

Fig. 36.—The Top Part of the Mould Stripped from the Casting, Illustrating the Even Spacing of the Runners.

Fig. 37.—Close-up View of One End of Liner.
(Note the divided contraction of 2 in.)

Fig. 38.—The other End of Liner.
(Again note the divided contraction of 2 in.)

Fig. 39.—Core for Periscope Section in Manganese Bronze.

(*Continued from previous page.*)

Fig. 40.—Mould for Periscope Section in Manganese Bronze Casting.

Fig. 41.—The Casting, with Runners and Feeders attached.

Fig. 46.—Another Stage of Operations on the Mould for the Propeller-Shaft Bracket.

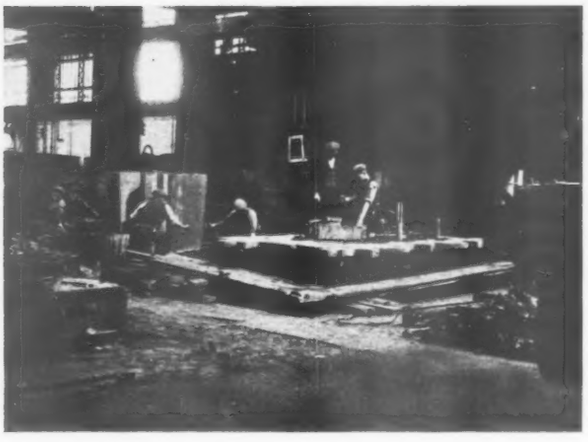

Fig. 47.—Top Parts being Constructed.

Fig. 50.—Another View of the Work of Finishing.

Fig. 51.—The Mould being Dried by means of Hot-Air Dryers.

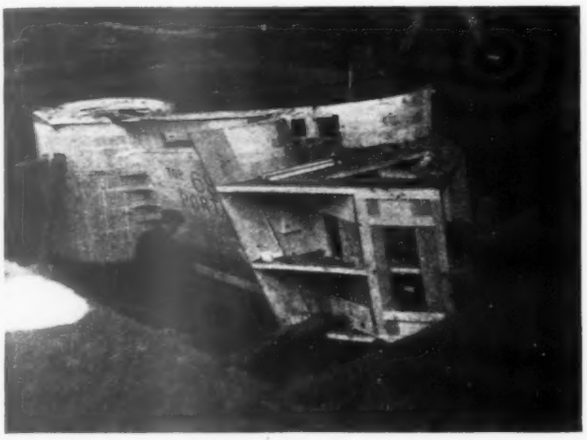

Fig. 44.—Pattern of Steel Propeller-Shaft Bracket set in Casting Position.

Fig. 45.—Joint being made.

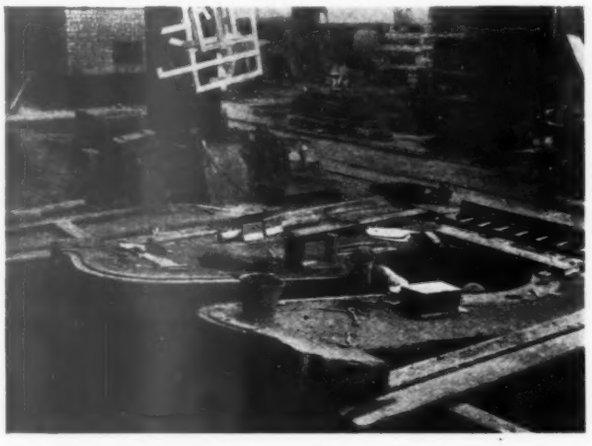

Fig. 48.—Finishing the Mould.

Fig. 49.—Finishing the Bracket Mould.

Fig. 52.—Mould for Piece of Cast-Steel Stern Frame.

Fig. 53.—Upper Part of the Mould for a Stern Frame Casting.

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Fig. 54.—Upper Part of the Mould for a Stern Frame Casting.

Fig. 55.—Stern Frame Castings Assembled.

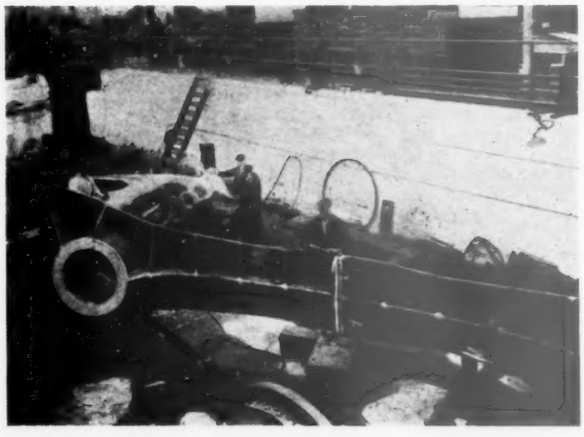

Fig. 56.—Stern Frame Castings Assembled.

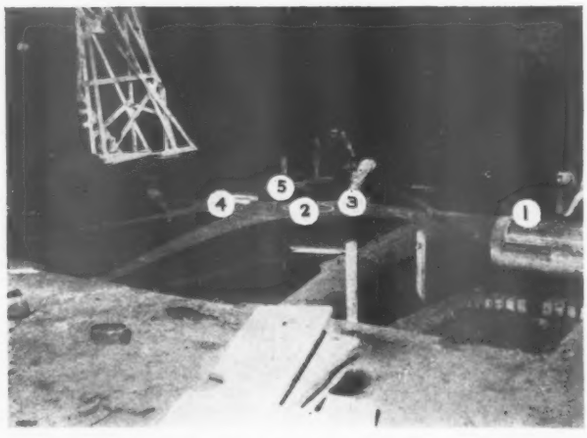

Fig. 57.—Pattern Set in Position and Rammed Under.

Fig. 58.—Building up the Drawbacks.

Fig. 59.—Another View of Drawback Construction.

Stern Frame Casting.—Figs. 52 *et seq.* show the importance of mould construction in connection with the correct building-up of all loose pieces to give the right thicknesses.

In Figs. 53 and 54 is shown the upper part of the mould with a drawback on the joint before insertion into the mould. In Figs. 55 and 56 are shown the completed castings after being fitted together.

Cast-Steel Rudder Frame.—Figs. 57 *et seq.* show the complete manufacture of a mould for a cast-steel rudder frame, and indicate the piecemeal building up of the various parts which go to make up the complete mould. The feeders are arranged at positions—1, 2, 3, 4 and 5 (Fig. 57)—and each is of sufficient capacity to permit ample feed of molten metal down each leg of the casting. There is no declivity in the casting position owing to the irregular thicknesses occurring in the design, which occur at the numbered positions. The bottom of the mould, it will be noticed, has been packed, and the joints around the pattern are being made, in preparation for the building of the sides of the mould.

Fig. 60.—Completion of Drawbacks and Joint made around the Pattern in readiness for commencing the Upper Half of the Mould.

Fig. 61. Construction of Top Parts of Mould.

The joints for the drawbacks in between the arms are carried below the pattern in order not to interfere with free movement of the arms to the main body of the casting during contraction. The estimated finished weight of the casting was 13½ tons. The allowances that have to be made for the feeding of castings of this description are about twice the finished weight to cast, and in this particular instance 23 tons of metal were used. The drawbacks are made in hollow form to obtain quick easing during the contraction period. One of the pieces of pattern in Fig. 58 has been removed, showing details of pattern construction, permitting the drawbacks to be made flimsily of loose irons and cinder material. Cast-iron grids would be too rigid to use in these drawbacks, and would reinforce the mould, thus hindering contraction. In Fig. 59 one of the drawback plates is ready for insertion, with others about one-half constructed.

The responsibility of the moulding operations is given to one of the best craftsmen, who can be seen in Fig. 59 between the two chains, setting his last drawback plate in position, with the remainder of the squad engaged on the other drawbacks. There is no crowding of workmen at any point, each member being busily engaged on different parts of the mould. The work, therefore, proceeds evenly as directed, by the assignment of duties to each member of the squad in connection with which supervision plays a most important part.

The upper half (Fig. 60) is in six separate pieces, in order to be able to strip it in sections, at periods of solidification determined by the varying thicknesses. A joint is used between each of the top parts which leaves gaps ¾ in. wide, and these are made up with sand after the mould is completely assembled. The construction of the top parts of the mould is by means of loose iron grids, the sand between which is reinforced by small pieces of soft bar iron bent and hooked on to the grids. This assists the lift of sand weight, giving the correct profile of the top half of the mould. One of the joints in the top half of the mould is shown, in Fig. 61, ready to receive other top parts, whilst another is being completed by three of the moulders on the right of the illustration.

Some of the feeders can be seen projecting through the grids, the clearance in which must be sufficient to give a thickness of sand to allow easy removal after casting. The grids are made under the supervision of the chargehand, a day of two before they are required, to the templates seen in the background of Fig. 62, to dimensions taken during various stages of manufacture of the mould. The top parts are shown completed, in Fig. 63, with the exception of the large centre part, which contains the main feeders or headers. It will be noted that all the small top parts may be removed before this large top part.

The manufacture of the top part on the lines indicated enables it to be removed in pieces, and allows the arms of the casting to contract freely as they solidify prior to the heavy sections being set. In this particular job the arms of the casting were black, whilst the main body under the large top parts was in liquid condition. It will be appreciated, therefore, how important is mould construction to facilitate contraction of the various thin parts in accordance with the varied rates of cooling.

Fig. 62.—Construction of Top Parts of Mould.

Fig. 63.—Construction of Top Parts of Mould.

(To be continued.)

Orders for eight steam locomotives and tenders for China, 21 large boilers for the Madras-Mahratta Railway, India, and a number of large boilers for the Egyptian State Railways, have been received by the Vulcan Foundry, Limited, Newton-le-Willows.

XUM

Continental Piston Practice

GERMAN EXCHANGE PAPER WELL RECEIVED

Referring to MR. W. A. GEISLER'S Paper* on "German Progress in Piston Rings, Brake Drums and Other Automobile Castings," MR. J. E. HURST said that he was gratified to be able to state that the author of the Paper was his personal friend and that he was present at the Conference. In addition to being a member, and the accredited representative, of the German Foundrymen's Association, he was also a member of the Institute. He had had the pleasure, upon a number of occasions, of seeing Mr. Geisler's plant and installation, together with his research laboratories. They were all extremely well equipped, and investigations were carried out with a thoroughness which was characteristic of work done in Germany.

Superiority Claimed for Centrifugally-Cast Rings

MR. T. R. TWIGGER wished to congratulate Mr. Geisler upon the excellence of his Paper which was particularly complete. To him, personally, being intimately connected with the making of piston rings and similar castings, the Paper was of very great interest. He noticed that Mr. Geisler made a comparison between single cast rings and rings made from centrifugal castings. Most of them would agree, from practical evidence in various countries, that the single casting in ordinary automobile practice did give satisfactory service, but to those of them who had been particularly concerned with the development of centrifugal castings it would be very gratifying to learn that for high efficiency piston rings required to stand up to exceedingly hard conditions the centrifugal casting offered much better scope. A point which Mr. Geisler did not appear to mention was the considerable difficulty experienced when dealing with rings of very narrow width, say 1½ m.m. as individual castings.

He understood that firms in various countries who advocated single cast rings had experienced that difficulty, and that for such narrow rings they found it necessary to use pot castings.

Cylinder Wall Pressure

The work which interested him most was that relating to the heat resistance, as Mr. Geisler expressed it, of piston rings, namely, the resistance to the setting of the ring under working temperatures. He had been carrying out work in regard to that point for at least two or three years upon lines very similar to those described by Mr. Geisler. Broadly speaking, the results confirmed those mentioned in the Paper. The loss of cylinder wall pressure on piston rings could be extremely serious, particularly in high-duty engines of the aircraft type. It was difficult to lay down what factors were responsible for this closing in or loss of pressure. The trouble was probably intimately connected with creep phenomena. From a practical point of view the tests carried out by Mr. Geisler in loading the rings in a gauge and heating them up for various periods was a very good way of testing different piston ring materials. The factors which entered into it such as the radial pressure of the rings, the temperature, and the time, which were often variable in actual engines, could be kept under control in laboratory experiments. It was not by any means an easy matter to lay down a formula; the creep continued over comparatively long periods of time. No doubt Mr. Geisler would still further continue with his research work. Mr. Twigger said he was very interested to learn that the rings which were formed by heat-shaping were better. This confirmed his own experience, personally. The loss of pressure in service on rings formed by heat was normally about half that on a ring shaped by internal hammering.

* FOUNDRY TRADE JOURNAL, August 8, 1935, p. 97.

Alloyed Piston Rings

He was interested in the inclusion of alloy constituents such as molybdenum, in connection with which he had carried out a number of tests, but somewhat erratic results as regards "heat resistance" had been obtained with molybdenum cast irons. There would probably be general agreement with Mr. Geisler's remarks concerning piston ring wear, although this was not by any means so serious a problem as that of cylinder wear. In regard to the amount of surface, over which piston rings travelled, it might be stated, generally, that piston ring wear was exceedingly small in relation to the cylinder wear.

Reference had been made to the possibility of improving piston ring cast iron by heat-treatment, but there did not appear to be any reference to hardening and tempering in the Paper. Some interesting results had been obtained with hardened and tempered rings of 12¾ in. diameter which had been run in a Diesel engine with ordinary cylinder liner material. The results on both piston ring wear and cylinder wear were exceptionally good.

Author's Reply

MR. GEISLER, in replying to the discussion, first wished to convey to the membership of the Institute of British Foundrymen the greetings of the Verein Deutscher Eisengiesserein Giessereiverband, who extended to the members of the Institute of British Foundrymen an invitation to participate in conventions in Germany. An international congress was scheduled for next year to be held early in May. English and German war veterans were now meeting together in fraternal intercourse at the prompting of the Prince of Wales, and therefore it might be regarded as quite a fitting thing for both English and German foundrymen periodically to foregather.

Case of Small Rings

He agreed with Mr. Twigger that narrow piston rings with an area of 2 m.m. thickness were easier cast centrifugally. In casting such small rings in single castings, a large quantity of iron was required, the gates and runners amounting to approximately 85 per cent., while there was only altogether about 5 per cent. for the piston rings. Furthermore, very little castings were easily made hard and had to be machined afterwards. For large rings of 40 to 50 m.m. individual casting could be adopted. If single-cast piston rings were put into Diesel engines or aircraft engines they did not stand up well to wear. It was necessary to add alloys such as chromium, etc. Small rings up to 3 or 4 m.m. sq. were difficult to alloy. Chromium and molybdenum were used to make the iron very hard, and in the case of single-cast piston rings they were difficult to machine. They had not much experience of heat-treated piston rings in Germany. It was only recently that hardened piston rings had been tried but with very good results, however.

Heat-Shaping of Rings

It had been found that the heat-shaping of rings gave good results. With regard to piston-ring wear, of course, the liner wear was most important. It was found that with aircraft duties or with Diesel engines wear occurred in the piston rings.

He had considered it advisable to mention the work done in Germany for a number of years with respect to brake bands. Combined steel and cast iron was more usual than merely cast-iron work referred to by Mr. Twigger, because of the fact that the combined brake was much lighter in weight and much safer. The revolving brake was quite efficient for slow cars and large lorries, but for pleasure cars invariably the steel-cast iron composite brake had been found to be more efficient in Germany.

MR. WILLIAMS, as the representative of a firm manufacturing centrifugal castings, confirmed Mr. Geisler's statement that centrifugal castings in the case of piston rings for high-duty engines were definitely superior to single cast rings.

MR. J. A. REYNOLDS felt that the opportunity should not be allowed to pass of responding to Mr. Geisler's invitation extended on behalf of the German Foundrymen's Society. He thought that the Institute should respond officially to the very welcome invitation which had been extended to them by their German colleagues.

Radial Pressure Determination

The PRESIDENT said he could add very little to what Mr. Twigger had said respecting piston rings because that gentleman's experience was so much greater than his own. Nevertheless, he had been concerned practically all his working life with the manufacture of centrifugal castings, the actual manufacture of piston rings having been the concern of others. This was, probably, the first occasion on which any British technical society had had placed before it some of the methods adopted by piston-ring manufacturers in the examination of piston rings. Figs. 6, 7 and 8 showed the actual results of the examination of piston rings for radial pressure, and gave some idea of the extent and the details of the methods adopted in carrying out investigations into the service value of such materials. As far as he was aware similar diagrams had not been published before in this country, though very extensive investigations had been published by a Japanese research worker, Mr. K. Ebihara, of Tokio. If that gentleman's very extensive publication was consulted, full details would be found of the types of machines used for studying the variation in radial wall pressure round the circumference of piston rings. Mr. Shaw had several time commented, in a somewhat cynical manner, on these tiny piston rings, but they were, nevertheless, a problem of very great interest to ironfounders in general. Even centrifugal castings and drum castings could be cut up into small rings. Perhaps one small drum casting having an average weight of something of the order of 7 lbs. was cut up into 20 or 30 rings, the user of those rings expecting each and every twentieth part of that casting to have absolutely identical physical and mechanical properties. It had been a long weary process to arrive at a stage of production which satisfied the modern piston-ring maker and motor-car engineer. Mr. Shaw could well remember during the war period the difficulties experienced by the War Department in obtaining uniformity of properties of piston rings. It had taken a long time to reach the state of perfection which had been obtained already. It was only by intensive methods of investigation that that success had been achieved. He hoped that Mr. Geisler would receive much more discussion of his Paper by correspondence.

Vote of Thanks

MR. F. J. COOK proposed a cordial vote of thanks to Mr. Geisler for his valuable Paper. Personally, he had received a great deal of consideration and pleasure when visiting Germany, and he hoped that Mr. Geisler would receive equal consideration and derive equal pleasure from his visit to this country.

The vote of thanks was seconded by the PRESIDENT and carried unanimously.

MR. GEISLER, in briefly responding to the vote of thanks, thanked the Institute of British Foundrymen for their invitation to attend their annual Conference, and for the kindness which had been extended to him during his visit to Sheffield.

XUM

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This Week's News in Brief

Trade Talk

MESSRS. WILLIAM DENNY & BROTHERS, LIMITED, Dumbarton, have secured an order to build a single-screw cargo steamer, 430 ft. long, for the Ellerman & Papayanni Lines.

MESSRS. BRIMS & COMPANY, LIMITED, Newcastle-upon-Tyne, have secured the contract for extending by 450 ft. the jetty at Palmer's Hebburn Company's ship-repairing yard and dry dock.

THE BELGIAN INTERNATIONAL CONGRESS COMMITTEE announces that invitations for participation have been accepted by Britain, Czecho-Slovakia, Denmark, France, Germany, Holland, Italy, Luxemburg, Poland, Spain, and the United States of America.

AN ORDER for two new ships, each of 9,000 tons deadweight, has been placed with the Caledon Shipbuilding & Engineering Company, Limited, Dundee, by Messrs. Christopher Salveson & Company, Limited, Leith. The machinery will be constructed and installed by Messrs. David Rowan & Company, Limited, Glasgow.

MESSRS G. & J. WEIR, LIMITED, Cathcart, Glasgow, have secured an order from the Italian Government for large and elaborate distillation plants for use in the Abyssinian campaign. The utilisation of these will convert suspect supplies into pure water. Such plant, of course, is not included in the embargo on the export of armaments.

LAID-UP SHIPPING in the Tyne is now further reduced. The "Flowergate" (5,156 tons), of London, which has been laid up at Jarrow for five and a-half years, has been refitted at the Mercantile Dry Dock, and has left for Alexandria. The "Ilvington Court" (5,187 tons), tied up since November, 1931, has proceeded to Archangel.

MESSRS. THERMOTANK, LIMITED, Helen Street, Govan, Glasgow, has secured a contract valued at £10,000 for air-conditioning equipment for the South African Parliamentary Buildings. This is one of several contracts which Messrs. Thermotank has received from South Africa during the past few months for air-conditioning work and mine ventilation.

LATEST MINISTRY OF LABOUR statistics compiled on Tyneside show a decrease of 4,162 adults in the number of unemployed on Tyneside at the end of July compared with three months earlier. Compared with a year ago the improvement is 2,680. This is attributed to general trade improvement, the building and shipbuilding trades being especially active.

HUNDREDS OF TONS of iron and steel will be required for the construction of a dam in the valley of the Carron in the Denny Hills, Stirlingshire. The contract has been awarded by the Falkirk and District Water Board to Messrs. Shanks & McEwan, Limited, contractors, West Nile Street, Glasgow, and is valued at £118,000. Work is to commence next month.

THE LONDON MIDLAND & SCOTTISH RAILWAY COMPANY have placed an order with the Fairfield Shipbuilding & Engineering Company, Limited, for a twin-screw passenger steamer for the Firth of Clyde service between Ardrossan and Arran in the summer and winter. The vessel will be about 250 ft. in length, with accommodation for 1,300 passengers. The propelling machinery will consist of geared turbines.

MESSRS. PETER & MARK HURLL, LIMITED, Garliston Works, Glenboig, have received an order for over 200,000 firebricks of varying sizes for an overseas corporation. Garliston works have been working at full capacity for some time on contracts for ironworks in the Midlands of England and in Belgium. The Garscadden works of the firm have been so busy that it has been found necessary to introduce a night shift to cope with the work in hand.

WE EXTEND sincere congratulations to one of our Indian subscribers, Messrs. Vithal Purshotum & Sons, engineers and ironfounders, of Sandhurst Road, 2nd Khetwady Lane, Bombay, on the seventieth anniversary of their establishment. The firm was established in 1865 by Mr. Purshotum Virchand and is now conducted by his grandson, Mr. Narotam Purshotum, assisted by son, the fourth generation, Mr. Shivdas Purshotum. The works have grown from small beginnings until now they employ about 100 persons.

MESSRS. GEORGE COHEN, SONS & COMPANY, LIMITED, have built large new showrooms for their secondhand machinery department at Wood Lane, Shepherd's Bush, London, W.12—adjacent to Wood Lane Tube Station, Central London Railway. From this address their secondhand machinery business, in London and Southern England, will in future be conducted. Customers who have been in the habit of writing on machinery matters to 600, Commercial Road, London, E.14, should in future write to Wood Lane, Shepherd's Bush, London, W.12. The firm's other addresses—including that of their head office, 600, Commercial Road, London, E.14—remain unchanged, and the sign of the firm will continue to be "600."

MESSRS. METAL INDUSTRIES, LIMITED, recently entertained their Scapa Flow salvage employees at a banquet and ball held at the Salvage Depôt at Lyness, on the Orkney Island of Hoy. The entertainment was given to celebrate the recent raising of the ex-German battleship Konig Albert, one of the vessels scuttled by the Germans 16 years ago. A pleasant feature of the function was the presentation of bonuses to the staff and workmen engaged on the salvage work, involving a four-figure sum. This was a special token of the firm's appreciation of the good work done at Scapa Flow. Mr. R. W. McCrone, Rosyth, the managing director of Metal Industries, Limited, and a director of British Oxygen, Limited, occupied the chair, and paid a glowing tribute to the excellent work of Mr. Thomas McKenzie, the Scapa manager, and his staff and workmen afloat and ashore.

Contracts Open

Bangkok, September 13.—200,000 kgs. of pig-iron, for the Royal State Railways of Siam. The Department of Overseas Trade. (Reference T.Y. 5,189.)

Brigg, September 10.—330 yds. 6-in., and 400 yds. 4.in. cast-iron water mains, sluice valves, hydrants and ancillary work, for the Urban District Council. Mr. N. D. Preston, surveyor.

Aberayron, September 7.—Spun and cast-iron pipes, 2-in. and 3-in. dit., for the Aberayron Rural District Council. Mr. J. Owen Parry, Ammanford. (Fee £2 2s. for each scheme, returnable.)

Llanybyther, September 7.—3-in. dia. cast-iron pipes, with valves, hydrants, standpipes, for the Aberayron Rural District Council. Mr. R. Jones, Llandyssul. (Fee £2 2s., returnable.)

Hingham, September 5.—Seven miles of 3-in., 4-in. and 5-in. spun-iron pipes, for the Forehoe and Henstead Rural District Council. Mr. A. J. Martin, 106, St. George's Square, Westminster, S.W.1. (Fee £3 3s., returnable.)

Godmanchester, September 6.—8,000 yds. of cast-iron or spun-iron water main, from 6-in. to 3-in. dia., for the Town Council. Messrs. Pick, Everard, Keay & Gimson, 6, Millstone Lane, Leicester. (Fee £2 2s. for each contract, returnable.)

Company Reports

Redheugh Iron & Steel Company, Limited.—Net profit for half-year to June 30, £4,385 (£4,078 for first half 1934), £820 brought in; dividend 2 per cent., on preference; 5 per cent. (same) on ordinary; carried forward £556.

Brightside Foundry & Engineering Company, Limited.—Net profit, £21,072; brought forward, £8,220; available, £29,292; deducting dividend for first half of year on preference shares, leaves available £27,042; dividend of 10 per cent., less tax, on £1 ordinary shares, £10,000; balance forward, £17,042. This company has a large number of important contracts in hand at the moment for firms both at home and abroad.

New Company

(From the Register compiled by Jordan & Sons Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Blackheath Ironfoundry, Limited, Oak Foundry, Holt Road, Blackheath, Staffs.—Capital £1,000. Directors: H. G. Evans, G. H. Mumford, H. Lloyd and H. Aingworth.

Personal

SIR WILLIAM ELLIS, the veteran steelworks director, last week celebrated his seventy-fifth birthday by climbing the Jungfrau.

MR. OLIVER SMALLEY, H.M. Consul at Pittsburgh and director of The International Meehanite Metal Company, Limited, sailed for America on Tuesday.

MR. OLIVER WILSON, son of Mr. F. P. Wilson, J.P., a Past-President of the Institute of British Foundrymen, has been appointed manager of Messrs. Thomas Wilkinson & Company, Limited, of Middlesbrough, the well-known manufacturers of coal dust, blacking, etc. Mr. Wilson has had foundry experience with Pease & Partners and S. Russell & Sons, Limited, of Leicester.

Wills

HUNTING, FREDERICK FORRESTER, of Cardiff, formerly of Hartshill, Stoke-on-Trent, chief metallurgist to British (Guest Keen Baldwins) Iron & Steel Company, Port Talbot £1,729

HEATON, WILLIAM, Moorlands, Hartopp Road, Four Oaks, Sutton Coldfield, managing director of William Hunt & Sons, Limited, Brades Steel Works, Oldbury £38,598

Obituary

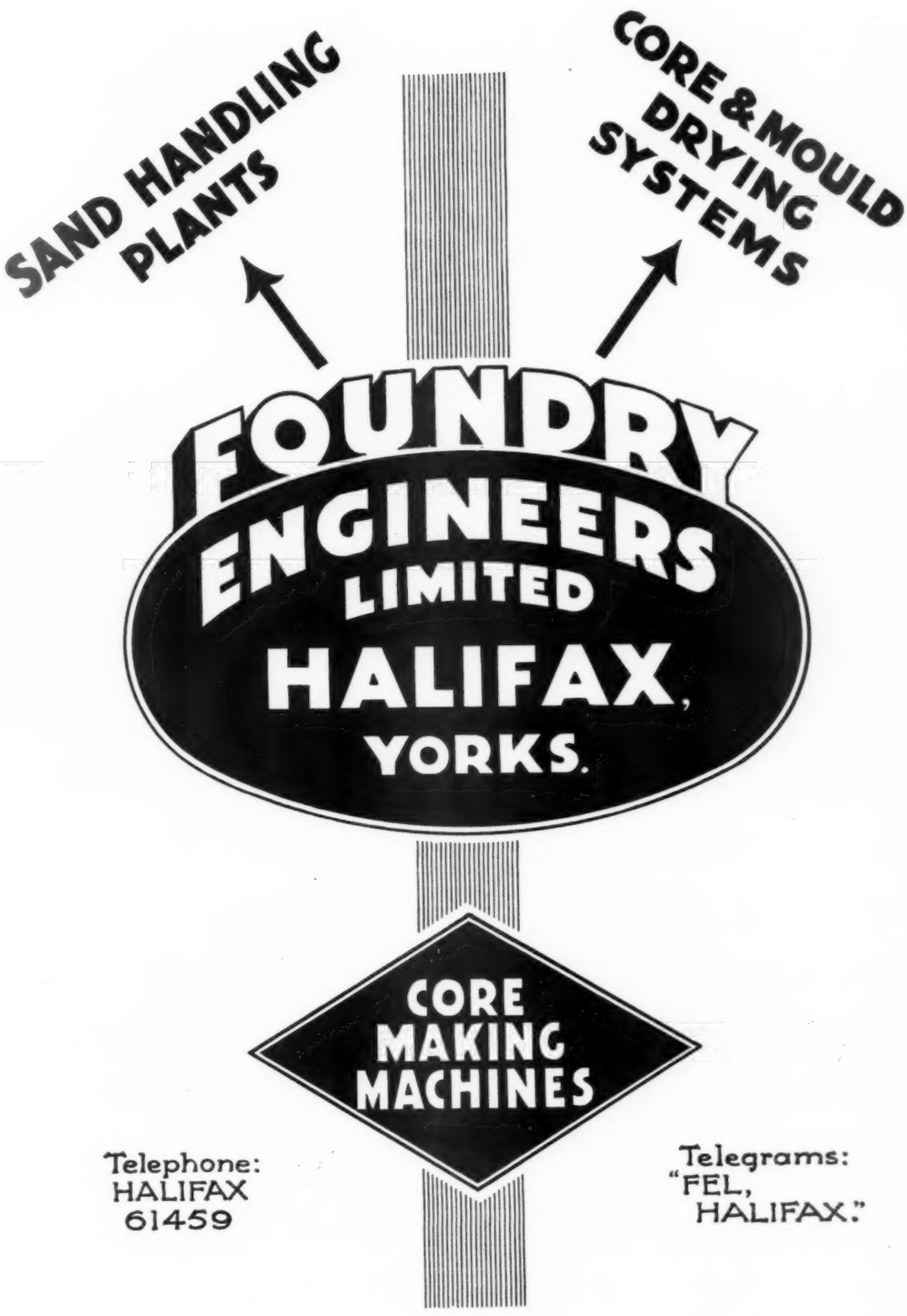
MR. HENRY CUNNINGHAM, who has died in his 70th year, retired a year or two ago from the Castlecary works of Messrs. John G. Stein & Company, Limited, where he had worked for many years. At the time of his retirement he was one of the oldest employees of the firm.

MR. WILLIAM MITCHELL, for some time foreman with the Grahamston Iron Company, and latterly works foreman with M'Dowall, Steven & Company, Laurieston, has died in his 85th year. He retired from the foundries 18 years ago, after having worked in them since his boyhood days. He was recognised as a particularly skilled moulder.

Catalogues Received

Wagon Tipplers. An extremely neat brochure has been received from the Fraser & Chalmers Engineering Works, Erith, which describes and illustrates a line of standard side-discharging wagon tipplers. This is a piece of mechanism which during the last decade has been introduced into the foundry industry with a considerable amount of success. It typifies a class of plant which many founders imagine to be too much of a refinement until they enter into the costs. It is specially applicable for the economic handling of moulding sand. The brochure, which is of a purely technical character, runs to eight pages and carries thirteen illustrations. There could usefully have been included a list of the raw materials for which wagon tipplers are particularly suited.

Crucible Furnaces. The Morgan Crucible Company, Limited, of Battersea Works, London, S.W.11, have prepared a new catalogue dealing with coke-fired crucible tilting furnaces. The letterpress is exceptionally well written and methodically set-out, each of the three main patterns available being dealt with in extended reference as to size and type. The working results obtained from these furnaces are tabulated on pages 16 and 17 and the figures of consumption reproduced are definitely conservative. The balance of the catalogue is devoted to the air supply, the necessary accessories, and the spares it is desirable to carry, together with some intelligently-compiled notes on coke and how to use it to the best advantage. We think the time is now ripe for including also the normal lives of crucibles for the various metals melted. We are aware of the existence of difficulties to be associated with accidents and real carelessness, yet ample data are now available to give an average appreciation on which one can base operating costs.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Raw Material Markets

Holiday interruptions are still giving the iron and steel trade a subdued appearance, but with the expiration of the current month an increased demand is expected. Order-books are fairly well filled, and many of the works are assured of employment beyond the end of the year. The outlook gives reason for general optimism and the demand, it is hoped, will rise above the highest level yet reached during the present revival in the iron and steel trade.

Pig-Iron

MIDDLESBROUGH.—Although the annual holiday week was held last week and there was no meeting of the Cleveland Iron Market; a number of small orders were carried through. Inquiries for fairly large tonnages up to the end of the year have been reported and the ironmasters are heavily booked. Deliveries of pig-iron for August are well above those for July. Scottish foundrymen's needs have increased and in all probability an addition in the output will have to be made. Export orders continue to be neglected in preference to home requirements. No. 3 Cleveland G.M.B. is 67s. 6d. delivered Middlesbrough, 69s. 6d. delivered North-East Coast, 67s. 3d. delivered Falkirk, and 70s. 3d. delivered Glasgow. No. 1 Cleveland foundry iron is 2s. 6d. per ton extra, and 1s. per ton discount is allowed on No. 4 foundry and No. 4 forge iron.

In spite of the recent increase in prices the output of East Coast hematite has had to be increased. Another furnace is being converted to hematite making in the district and this will bring the total up to ten. Home steelworks are taking large tonnages of hematite and Italian buyers are pressing for a resumption of shipments to their country. Fixed prices for home purchases are as follow:—No. 1 East Coast grade 71s. per ton delivered Middlesbrough, 72s. delivered Tyneside, 73s. 6d. delivered North-East Coast, 77s. 6d. delivered Scotland, 78s. 6d. delivered Sheffield, and 84s. 6d. delivered Birmingham.

LANCASHIRE.—The demand for foundry pig-iron is still under holiday suppression in this area and only a slight rise in customers' requirements has been noted. The local opinion is that it will be well into September before trading conditions reach normal proportions. Derbyshire and other Midland brands of iron have experienced a fair demand, but the call for hematite has been only moderate. For delivery to consumers in the Lancashire price zone, current offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 foundry iron, equal to Derbyshire, are all on the basis of 74s. per ton, with Northamptonshire iron at 72s. 6d., and Scottish No. 3 at around 81s. 6d. East Coast brands of hematite iron are quoted for delivery equal to Manchester at from about 80s. to 81s. per ton, according to grade, and West Coast hematite is at around 81s.

MIDLANDS.—There has been very little forward buying in this area, but on the whole, specifications have been tendered reasonably well considering the time of year. The C.P.I.P.A. official minimum quotations delivered Birmingham and Black Country stations, and subject to rebate for large consumers, are 67s. 6d. per ton for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. Forge pig-iron is still quoted 5s. per ton below No. 3 grade. Scottish No. 3 ranges from 85s. to 90s., with other brands of similar analysis from 72s. to 82s. 6d. per ton. Refined brands of iron are quoted at from £5 7s. 6d. to £7 per ton delivered this district. Very little new business has been reported in hematite and prices are as follow:—West Coast mixed numbers of foundry grades is 84s. 6d. per ton, and East Coast No. 1 is at the same level, with No. 3 6s. per ton less. 83s. per ton is the price fixed by Welsh makers for mixed numbers. All prices are delivered works, South Staffordshire, in 10-ton lots, net, with no rebate.

SCOTLAND.—A steady demand continues for pig-iron of all brands in this area, except for Scottish foundry iron which has a poor following. No. 3 is still quoted officially at 70s. per ton f.o.t. furnaces, with an additional 2s. 6d. per ton for No. 1. Cleveland prices show no alteration from those quoted last week and are as follow:—67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow for No. 3 foundry. Other English foundry iron are quoted at 1s. 3d. per ton less. The recent revival in the shipbuilding industry has led to greater activity at the steelworks. No change in prices of steelmaking irons has been noted and they are as follow:—Mixed numbers Scottish hematite 71s., ordinary mixed numbers West Coast hematite 75s., ordinary mixed numbers East Coast hematite 77s. 6d., basic, British and Indian 70s., less 5s. rebate, all delivered f.o.t. steelworks here.

Coke

The coke market has not progressed along with the greater activity shown in other markets and it is still quiet. Best Durham coke is offered at from 34s. to 40s., Welsh from 31s. to 43s. 6d., and Scottish low-ash coke at about 39s. to 41s. All prices are delivered Birmingham and district.

Steel

Steady conditions rule in the steel markets, but trading is less active than in the early part of the month, when consumers showed a tendency to cover forward, says the official report of the London Iron and Steel Exchange. New business in most departments is rather quiet, but considering the time of year good deliveries are being made to the consuming industries. Business in semi-finished steel is active and a feature of the position in this department is the heavy deliveries which are being made. The Continental quota of this material for the current period is said to have been sold, but the quantities disposed of were not sufficient to exercise any influence upon the demand for British steel. A considerable volume of business is passing in finished materials and in particular the demand for structural steel is at a high level. Export business is quiet, but lately a fair amount of inquiry has been received from oversea markets, which encourages hopes of an expansion in this direction.

Scrap

Owing to the holidays in the Cleveland district deliveries were suspended for last week. Local steelworks have continued to take up their usual volumes and they still offer 52s. 6d. per ton as a delivered price for heavy melting steel for future transactions. Having disposed of large quantities, merchants are now rather cautious about further dealings. Nominally heavy foundry cast iron is unchanged at 52s. 6d. per ton and machinery metal in handy pieces at 55s. Light iron is at 42s. and heavy steel turnings and cast-iron borings are at 37s. 6d. and 27s. 6d. per ton respectively. The South Wales scrap market still continues to show very featureless business. The majority of local steelworks are well covered and consequently new business is very limited. Heavy mild-steel scrap in furnace sizes is without much movement at 55s. to 56s. Bundled steel scrap is at 51s. to 54s., and good, clean, heavy, mild-steel turnings have a fair demand in small parcels at 45s. to 46s. Mixed wrought-iron and steel scrap for basic furnaces is steady at 50s. to 52s. and compressed basic bundles are at 48s. to 50s. Light cast iron is in small demand at 42s. 6d. to 45s. and good cast-iron machinery scrap in cupola sizes still has a small local following at 52s. 6d. to 55s.

New business on the Midland market is very scarce and most consumers are well covered. Heavy steel in furnace sizes is at 44s. to 45s. and mixed heavy iron and steel is at 42s. 6d. to 43s. 6d. Steel turnings have a small demand at 34s. Heavy wrought iron is in poor call at 57s. 6d., while heavy machinery in cupola sizes is at 55s. to 57s. 6d.; good heavy at 50s. and clean light at 47s. 6d. Short, heavy steel scrap for foundry uses is at 55s., delivered locally. Very little alteration has occurred in the condition of the Scottish markets and prices remain firm. First quality heavy-steel melting scrap in furnace sizes is still at 50s. per ton with heavy basic or heavy iron and steel scrap mixed at 45s. Clean cast-iron borings are at 37s. 6d. to 38s. 6d. per ton and machinery cast-iron scrap, in pieces not exceeding 1 cwt., for foundry purposes, are still at 56s. 6d. to 57s. 6d. per ton.

Metals

Copper.—Since last Thursday, when the copper market reacted in rather a sharp manner, the general tone has been rather irregular. Consumption is well maintained and reports from the United States give cause for growing optimism as far as that country is concerned. The confidence of the market was shaken recently as a result of the Italian-Abyssinian dispute, but apart from political differences the state of the market should further improve. Returning to the United States market, over 68,000 tons were sold on Monday, August 19, and this makes the total sales in three days 86,000 tons and for the month up till that day, 100,000 tons, which is the largest total of any month for more than a year.

Daily market prices:—

Cash.—Thursday, £33 3s. 9d. to £33 5s.; Friday, £33 5s. to £33 6s. 3d.; Monday, £33 15s. to £33 17s. 6d.; Tuesday, £33 12s. 6d. to £33 13s. 9d.; Wednesday, £33 3s. 9d. to £33 5s. 0d.

Three Months.—Thursday, £33 11s. 3d. to £33 12s. 6d.; Friday, £33 12s. 6d. to £33 13s. 9d.; Monday, £34 3s. 9d. to £34 5s.; Tuesday, £34 to £34 1s. 3d.; Wednesday, £33 11s. 3d. to £33 12s. 6d.

Tin.—This metal has made further headway towards a recovery from the setback it received some time ago. Consumption is satisfactory both in this country and on the Continent. Shipments have recently been made from London to Holland of Banco-tin which is in good demand in that country. According to the August issue of the Bulletin of the International Tin Research and Development Council, the world production of tin in the first half of 1935 was 51,071 long tons, compared with 50,753 tons in the first half of 1934. The apparent world consumption of tin in the first half of 1935 increased by over 14 per cent. to 67,450 tons, compared with 58,959 tons in the first half of 1934. Tin consumption of the U.S.S.R in the year ended June, 1935, at 6,315 tons, is the highest recorded for that country, and represents an increase of 27 per cent. over the previous year. Important increases are recorded also for Italy, 18.4 per cent.; India, 15.6 per cent.; Canada, 18.5 per cent.; Sweden, 16.2 per cent., and Holland, 23.4 per cent.

Day-to-day fluctuations:—

Cash.—Thursday, £221 to £221 10s.; Friday, £220 to £220 10s.; Monday, £221 to £221 10s.; Tuesday, £220 10s. to £220 15s.; Wednesday, £220 10s. to £221 0s. 0d.

Three Months.—Thursday, £214 10s. to £214 15s.; Friday, £212 10s. to £212 15s.; Monday, £211 to £211 10s.; Tuesday, £210 10s. to £210 15s.; Wednesday, £210 10s. to £210 15s.

Spelter.—A firm tone has prevailed on this market and more active conditions have been noted. Consumption in this country is well maintained and reports from Continental centres state that conditions are steady. New rates of duty on imported spelter into this country have been announced by the Treasury, they came into force yesterday. The new duty is 12s. 6d. per ton or 10 per cent. *ad valorem*, whichever is the less.

Official quotations were as follow:—

Ordinary.—Thursday, £15 1s. 3d.; Friday, £15; Monday, £15 2s. 6d.; Tuesday, £15 6s. 3d.; Wednesday, £15 8s. 9d.

Lead.—The general impression is that the statistical position of lead has improved in recent months and this fact has given greater confidence to the market. Consumption in Great Britain has been well maintained and the Continent remains a good purchaser. The new duty on imported lead is 7s. 6d. per ton, or 10 per cent. *ad valorem*, whichever is the less, and this came into being yesterday on the recommendation of the Import Duties Advisory Committee.

Day-to-day quotations:—

Soft Foreign (*Prompt*).—Thursday, £16 2s. 6d.; Friday, £16; Monday, £16; Tuesday, £16 1s. 3d.; Wednesday, £16.

Japanese Pig-Iron Imports

After long negotiations, the Nippon Seitetsu and the Japan Pig-Iron Sales Guild are reported to have concluded a convention in regard to the importation of foreign pig-iron. Under the convention, all Indian pig-iron will be imported as hitherto through the Pig-Iron Sales Guild, while Soviet and Manchoukuoan pig-iron will be imported by the Nippon Seitetsu; arrangements will be made between the Seitetsu and the Sales Guild as to the import tonnages of foreign pig-iron and various other matters, so as not to disturb the balance between supply and demand on the market.

XUM

Sterling

MOULDING BOXES

ARE THE GREATEST ECONOMY
YOU CAN INTRODUCE INTO
YOUR FOUNDRY

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THEY SPEED UP PRODUCTION
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SAVE UNNECESSARY LABOUR

OVER 30 STANDARD DESIGNS OF BOXES

Consult us
AND LET US SOLVE YOUR MOULDING BOX PROBLEMS—

STERLING FOUNDRY SPECIALTIES LTD
BEDFORD
LONDON OFFICE: 13 VICTORIA STREET · WESTMINSTER · S.W.1

RAW MATERIALS—PRICE LIST

(Wednesday, August 28, 1935)

COPPER

	£	s.	d.
Standard cash	33	3	9
Three months	33	11	3
Electrolytic	36	15	0
Tough	35	15	0
Best selected	36	5	0
Sheets	64	0	0
India	47	15	0
Wire bars	37	15	0
Ingot bars	37	12	6
H.C. wire rods	41	5	0
Off. av. cash, July	31	1	4 2/3
Do., 3 mths., July	31	9	7 5/6
Do., Sttlmnt., July	31	1	7 1/3
Do., Electro, July	34	11	10 1/3
Do., B.S., July	33	16	11 1/3
Do., wire bars, July	34	18	5 1/3
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			6d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	220	10	0
Three months	210	10	0
English	220	10	0
Bars	221	10	0
Straits (nom.)	211	0	0
Australian (nom.)	211	0	0
Eastern	218	5	0
Banca (nom.)	212	10	0
Off. av. cash, July	232	12	7 3/13
Do., 3 mths., July	233	8	8 2/13
Do., Sttlmt., July	232	14	4 3/13

SPELTER

	£	s.	d.
Ordinary	15	8	9
Remelted	15	15	0
Hard	12	10	0
Electro 99.9	18	1	3
English	16	5	0
India	13	10	0
Zinc dust	19	10	0
Zinc ashes	3	5	0
Off. aver., July	14	2	6
Aver. spot, July	14	1	3 1/13

LEAD

	£	s.	d.
Soft foreign ppt.	16	0	0
Empire (nom.)	17	5	0
English	18	0	0
Off. average, July	14	9	7 10/13
Average spot, July	14	9	0 2/13

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	5	0
Do., V.M. ex-whse.	24	10	0
Rods	29	0	0

ANTIMONY

	£	s.	d.		£	s.	d.
English	74	0	0	to	75	0	0
Chinese, ex-whse.					68	0	0
Crude, c.i.f.					28	0	0

QUICKSILVER

Quicksilver	11	2	6	to	11	12	6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 15 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£33 10 0
4/6% car.	£21 15 0
6/8% car.	£21 0 0
8/10% car.	£21 0 0
Ferro-chrome—	
Max. 2% car.	£34 0 0
Max. 1% car.	£36 5 0
Max. 0.70% car.	£37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to 11 5 0
76/80% packed	£11 15 0 to 12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ½ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel	2	15	0	to	2	16	0
Bundled shrngs.	2	7	6	to	2	16	0
Mixed iron and steel	2	10	0	to	2	12	0
Heavy cast iron	2	10	0	to	2	12	0
Good machinery	2	12	6	to	2	15	0
Cleveland—							
Heavy steel					2	12	6
Steel turnings					1	17	6
Cast-iron borings					1	7	6
Heavy cast iron					2	12	6
Heavy machinery					2	15	0
Midlands—							
Light cast-iron scrap					2	7	6
Heavy wrought iron					2	17	6
Steel turnings					1	14	0
Scotland—							
Heavy steel					2	10	0
Ordinary cast iron					2	12	6
Engineers' turnings					2	0	0
Cast-iron borings	1	17	6	to	1	18	9
Wrot-iron piling					2	18	0
Heavy machinery					2	16	6

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	27	0	0
Brass	18	0	0
Lead (less usual draft)	14	0	0
Tea lead	10	0	0
Zinc	9	10	0
New aluminium cuttings	67	0	0
Braziery copper	23	0	0
Gunmetal	25	0	0
Hollow pewter	150	0	0
Shaped black pewter	116	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	71/-
Hematite M/Nos.	70/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	75/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	81/6
Clyde, No. 3	81/6
Monkland, No. 3	81/6
Summerlee, No. 3	81/6
Eglinton, No. 3	81/6
Gartsherrie, No. 3	81/6
Shotts, No. 3	81/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	9	12	6	and up.			
Nut and bolt iron	7	10	0	to	8	0	0
Hoops	10	10	0	and up.			
Marked bars (Staffs) f.o.t.	12	0	0				
Gas strip	10	10	0	and up.			
Bolts and nuts, ¾ in. × 4 in.	14	2	6	and up.			
Steel—							
Plates, ship, etc.	8	15	0	to	8	17	6
Boiler plts.	9	5	0	to	9	7	6
Chequer plts.	10	7	6				
Angles	8	7	6				
Tees	9	7	6				
Joists	8	15	0				
Rounds and squares, 3 in. to 5½ in.	9	7	6				
Rounds under 3 in. to ¼ in. (Untested)	8	12	0				
Flats—8 in. wide and over	8	12	6				
,, under 8 in. and over 5 in.	8	17	6				
Rails, heavy	8	5	0	to	8	10	0
Fishplates	12	5	0	to	12	10	0
Hoops (Staffs)	9	7	0				
Black sheets, 24g. (4-t. lots)	11	0	0				
Galv. cor. shts. (,,)	13	0	0				
Galv. flat shts. (,,)	13	10	0				
Galv. fencing wire, 8g. plain	14	10	0				
Billets, soft	5	10	0	and up.			
Billets, hard	6	17	6	to	7	2	6
Sheet bars	5	5	0	to	5	10	0
Tin bars	5	5	0	to	5	10	0

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9¾d.
Sheet to 10 w.g.	11½d.
Wire	12d.
Rods	11d.
Tubes	13½d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 21/-
Durham foundry	20/- to 21/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/2 and up.
,,	28×20	,,	36/4 and up.
,,	20×10	,,	26/- to 26/3
,,	18¾×14	,,	18/9 to 19/-
C.W.	20×14	,,	15/6
,,	28×20	,,	32/6
,,	20×10	,,	22/9
,,	18¾×14	,,	15/6

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£30	0	0	to	£31	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.	
Aug. 22 ..	33	3	9	dec. 3/9
„ 23 ..	33	5	0	inc. 1/3
„ 26 ..	33	15	0	„ 10/-
„ 27 ..	33	12	6	dec. 2/6
„ 28 ..	33	3	9	„ 8/9

Electrolytic Copper

	£	s.	d.	
Aug. 22 ..	36	10	0	dec. 5/-
„ 23 ..	36	10	0	No change
„ 26 ..	37	0	0	inc. 10/-
„ 27 ..	37	0	0	No change
„ 28 ..	36	15	0	dec. 5/-

Standard Tin (cash)

	£	s.	d.	
Aug. 22 ..	221	0	0	dec. 20/-
„ 23 ..	220	0	0	„ 20/-
„ 26 ..	221	0	0	inc. 20/-
„ 27 ..	220	10	0	dec. 10/-
„ 28 ..	220	10	0	No change

Tin (English ingots)

	£	s.	d.	
Aug. 22 ..	221	0	0	dec. 20/-
„ 23 ..	220	0	0	„ 20/-
„ 26 ..	221	10	0	inc. 30/-
„ 27 ..	220	10	0	dec. 20/-
„ 28 ..	220	10	0	No change

Spelter (ordinary)

	£	s.	d.	
Aug. 22 ..	15	1	3	inc. 1/3
„ 23 ..	15	0	0	dec. 1/3
„ 26 ..	15	2	6	inc. 2/6
„ 27 ..	15	6	3	„ 3/9
„ 28 ..	15	8	9	„ 2/6

Spelter (Electro, 99.9 per cent.)

	£	s.	d.	
Aug. 22 ..	17	13	9	inc. 9d.
„ 23 ..	17	12	6	dec. 1/3
„ 26 ..	17	15	0	inc. 2/6
„ 27 ..	17	18	9	„ 3/9
„ 28 ..	18	1	3	„ 2/6

Zinc Sheets (English)

	£	s.	d.	
Aug. 22 ..	23	7	6	inc. 2/6
„ 23 ..	23	5	0	dec. 2/6
„ 26 ..	23	5	0	No change
„ 27 ..	23	5	0	„ „
„ 28 ..	23	5	0	„ „

Lead (English)

	£	s.	d.	
Aug. 22 ..	18	0	0	No change
„ 23 ..	18	0	0	„ „
„ 26 ..	18	0	0	„ „
„ 27 ..	18	0	0	„ „
„ 28 ..	18	0	0	„ „

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 ? 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 15 6	0 15 5½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 6	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 5½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½	
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6	1 1 0	1 1 6	1 1 6	—	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 0	1 3 2½	1 4 0	1 4 8½	1 4 7½	1 4 6	1 4 6	1 4 3	1 3 7½
1930	1 3 3½	1 2 6	1 1 9	1 1 6	1 0 10½	1 0 0	1 0 0	0 19 6	0 19 0	0 17 4½	0 16 4½	0 16 4½	0 19 10½
1931	0 16 1½	0 16 0	0 16 0	0 15 11½	0 15 4½	0 15 0½	0 14 10½	0 14 3½	0 14 6	0 16 8½	0 17 0½	0 16 6	0 15 9
1932	0 16 6	0 16 6	0 16 3	0 15 6	0 15 4½	0 15 0	0 14 11	0 14 8½	0 14 6	0 14 6	0 14 9	0 15 1	0 15 3½
1933	0 15 6	0 15 3	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 11½	0 16 6	0 16 6	0 15 7½
1934	0 16 6	0 17 6	0 16 9	0 16 6½	0 16 8½	0 16 9½	0 17 0	0 17 0	0 17 0	0 17 0	0 17 0	0 17 0	0 16 10½
1935	0 17 0	0 17 4½	0 17 6	0 17 6	0 17 6	0 17 6	0 17 6	—	—	—	—	—	—

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